

10/561218

New U.S. National Stage of

PCT/JP2004/010083

IAPO Rec'd PCT/PTO 19 DEC 2009

# CLEAN COPY OF SUBSTITUTE SPECIFICATION

Surface Tension Control Agent for Coating Material and Coating Material  
Containing Same

#### Technical Field

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The present invention relates to a surface tension control agent for coating materials for appropriately controlling a surface tension of a coated layer of the coating material, and a coating material containing the same.

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#### Background Art

When a coating material is coated on a surface of plastic articles, etc., such phenomena as color separation, remaining of foams, poor leveling, poor wetting etc. often occur. To prevent these phenomena, additives such as silicone resin etc., which decrease surface tension of the coated layer, have been beforehand added into the coating material.

Japanese Patent Provisional Publication No. 09-255754 discloses a silicone type polymer that is added, as a leveling agent and/or defoaming agent for paint, into a cure type composition.

However, in this case, over-coatability onto a coated layer or anti-fouling property of the coated layer tends to be deteriorated when the surface tension of the coated layer is substantially lowered.

The present invention is made to solve the above mentioned problems. An object of the present invention is to provide a surface tension control agent for coating materials, which are used for suitably

controlling a surface tension of a coated layer of the coating material and giving the coated layer an excellent over-coatability and/or anti-fouling property, and a coating material containing the same.

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## Disclosure of Invention

A surface tension control agent for coating materials of the present invention which was aimed at achieving the foregoing objects comprises a fluorine-containing (meth)acrylic type copolymer which is  
10 obtained by copolymerization of monomers consisting of: a fluorine-substituted alkyl (meth)acrylate monomer (A), an alkyl (meth)acrylate monomer having an alkyl group selected from the group consisting of lauryl and stearyl, or n-butyl acrylate monomer (B) and a hydroxyl group- or ether group -substituted alkyl (meth)acrylate monomer  
15 (C), wherein the ratio of (A) to {(B)+(C)} in the copolymer is in the range of 3~60 parts by weight to 40~97 parts by weight.

Similarly, a surface tension control agent for coating materials of the present invention comprises a fluorine-containing (meth)acrylate type copolymer that is obtained by copolymerization of the monomer (A), the  
20 monomer (B), the monomer (C) and at least one kind of vinyl monomer (D) selected from the group consisting of styrene, alkyl vinyl ether, alpha-olefin and maleic anhydride.

Preferably, a weight-average molecular weight of the fluorine-containing (meth)acrylate type copolymer is in the range of  
25 1,500-300,000. Under 1,500, properties of a coated layer become poor. On the contrary, over 300,000, viscosity of the coating material becomes

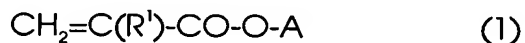
too high, being difficult in handling.

The monomer (A) is an alkyl (meth)acrylate having a perfluoroalkyl group with 2-18 carbon atoms. More specifically, trifluoroethyl methacrylate, tetrafluoropropyl methacrylate, perfluorooctyl ethyl  
5 methacrylate, and perfluorooctyl ethyl acrylate can be exemplified as the monomer (A).

The monomer (A) is preferably used in the range of 3-60 parts by weight in the copolymer. Below 3 parts by weight, surface tension of the coated layer becomes too high, being undesirable. Over 60 parts by  
10 weight, solubility thereof becomes poor, being difficult to prepare.

As the monomer (B), the alkyl (meth)acrylate monomer having the alkyl group selected from the group consisting of lauryl and stearyl, or n-butyl acrylate monomer, can be exemplified.

The monomer (C) is at least one kind of hydroxyl group- or ether  
15 group-containing alkyl (meth)acrylate represented by the following formula (1)



(where  $\text{R}^1$  is hydrogen atom or methyl group; -A is a hydroxyl alkyl group with 2-4 carbon atoms or an alkyl substituent thereof, an alkyl  
20 monoalkylene glycol group having an alkyl group with 1-18 carbon atoms, an alkyl polyalkylene glycol group having an alkyl group with 1-18 carbon atoms, an alkenyl monoalkylene glycol group having an alkenyl group with 2-18 carbon atoms, or an alkenyl group-substituted polyalkylene glycol group having an alkenyl group with 2-18 carbon atoms).

25 For example, 2-hydroxyethyl acrylate, methoxy triethyleneglycol methacrylate, butoxyethyl methacrylate, 2-hydroxypropyl methacrylate,

polyethylene glycol polypropylene glycol mono-methacrylate, polyethylene glycol polytetramethylene glycol mono-methacrylate can be exemplified as the monomer (C).

For example, styrene, straight- or branched-chain or cyclic alkylvinylether, alpha-olefin and maleic anhydride can be exemplified as the monomer (D). The monomer (D) is preferably used in the copolymer in the range of 1-40 parts by weight.

The present surface tension control agent for coating materials comprises, for example, the fluorine-containing (meth)acrylate type copolymer dissolved in an inactive solvent.

The inert solvent is preferably a solvent capable of dissolving the fluorine-containing (meth)acrylate type copolymer and miscible with the coating material etc. More specifically, an aromatic solvent such as xylene etc., a propylene glycol type solvent such as propylene glycol monomethyl ether etc., an alcohol type solvent such as 3-methyl-3-methoxy butanol etc. can be exemplified as such solvent. These solvents can be used alone or in combination.

The coating material of the present invention contains the surface tension control agent for coating materials of the present invention. The component of the coating material can include such ingredients, other than the surface tension control agent, as acrylic resin, polyester resin, urethane resin, alkyd resin, epoxy resin etc. or various reactive polymers, oligomers, or monomers. Acrylic resin is preferably used as such ingredient.

Mode for Carrying Out the Invention

The fluorine-containing (meth)acrylate type copolymer, a component of the surface tension control agent for coating materials of the present invention, is obtained as follows. The copolymer is  
5 polymerized through random polymerization by adding the monomer (A), monomer (B), monomer (C) and monomer (D) dropwise into a solvent in the presence of a radical polymerization initiator under a heated condition. The copolymer can alternatively be obtained through block-copolymerization by adding monomer (A), (B), (C) and (D)  
10 separately into a solvent in the presence of a block-copolymerization initiator under a heated condition.

As the radical polymerization initiator, peroxide, azo compound etc., which are generally used in radical polymerization, can be used. More specifically, di-tert-butyl peroxide (PERBUTYL D; product by NOF  
15 CORPORATION), PERBUTYL O (product by NOF CORPORATION), PERTETRA A (product by NOF CORPORATION) etc. can be exemplified.

As the block-copolymerization initiator, a two-stage decomposing type initiator with two functional groups such as 1,1-bis-(tert-butyl peroxy)-2-methyl cyclohexane can be exemplified.

20 The surface tension control agent for coating materials of the present invention can be applied for both aqueous- and non-aqueous coating systems.

The coating material of the present invention is prepared by adding the surface tension control agent for coating materials of the  
25 present invention into a commonly used coating material which is prepared previously, and by mixing them. Solid content of 0.05-2.0% by

weight, preferably 0.1-1.0% by weight, of the surface tension control agent for coating materials is added, on the basis of the coating material, to the coating material. A coated layer having an appropriately adjusted surface tension is obtained from the thus prepared coating material.

5 (Application to aqueous coating materials)

Examples of aqueous coating materials containing the surface tension control agent for coating materials of the present invention are shown in Examples 1 to 4. Comparative Examples of aqueous coating materials containing a surface tension coating agent for coating materials  
10 outside the present invention are shown in Comparative Examples 1 to 3.  
(Example 1)

150 parts by weight of 3-methyl-3-methoxy butanol (SOLFIT, product by KURARAY Co., Ltd.) was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid  
15 inside the vessel was kept at 120°C. A mixed solution of 5 parts by weight of trifluoroethyl methacrylate (LIGHT ESTER M-3F, product by KYOEISHA CHEMICAL Co., Ltd.), 47.5 parts by weight of methyl methacrylate, 47.5 parts by weight of 2-hydroxyethyl acrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise added into  
20 SOLFIT under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer. Weight-average molecular weight of the thus obtained fluorine-containing (meth)acrylate type copolymer in the solution was determined using a gel-permeation chromatography. The  
25 molecular weight thereof was 11,000 in terms of polystyrene.

Next, 0.75g of the thus obtained solution containing

fluorine-containing (meth)acrylate type copolymer was added to 30g of Water Base House Paint Emulsion Coating BLUE (product by ASAHIPEN CORPORATION) and 30g of Water Base House Paint Emulsion Coating WHITE (product by ASAHIPEN CORPORATION). Then the mixture was  
5 mixed at a rotation speed of 3,000 rpm for 3 minutes using Labodisper, obtaining an aqueous type coating material.

(Example 2)

150 parts by weight of SOLFIT (product by KURARAY Co., Ltd.) was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer  
10 and dropping funnel, and the liquid inside the vessel was kept at 120°C. A mixed solution of 40 parts by weight of LIGHT ESTER M-3F (product by KYOEISHA CHEMICAL Co., Ltd.), 30 parts by weight of ethylhexyl methacrylate, 30 parts by weight of 2-hydroxyethyl acrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise  
15 added into SOLFIT under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer. Weight-average molecular weight of the thus obtained fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation  
20 chromatography. The molecular weight thereof was 35,000 in terms of polystyrene.

Then an aqueous type coating material was prepared according to Example 1 except that the thus obtained solution containing fluorine-containing (meth)acryl type copolymer was used instead of the  
25 solution containing the fluorine-containing (meth)acryl type copolymer in Example 1.



(Example 3)

150 parts by weight of SOLFIT (product by KURARAY Co., Ltd.) was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 120°C.

- 5 A mixed solution of 15 parts by weight of LIGHT ESTER M-3F (product of KYOEISHA CHEMICAL Co., Ltd.), 30 parts by weight of butyl methacrylate, 55 parts by weight of 2-hydroxy ethylacrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise added into SOLFIT under nitrogen over about 1 hour. Reaction was continued for 2
- 10 hours at 120°C, obtaining a solution containing fluorine-containing (meth)acryl-type copolymer. Weight-average molecular weight of the thus obtained fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The molecular weight thereof was 15,000 in terms of polystyrene.

- 15 Then an aqueous type coating material was prepared according to Example 1 except that the thus obtained solution containing fluorine-containing (meth)acryl type copolymer was used instead of the solution containing the fluorine-containing (meth)acryl type copolymer in Example 1.

20 (Example 4)

- 200 parts by weight of SOLFIT (product by KURARAY Co., Ltd.) was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 110°C. A mixed solution of 20 parts by weight of perfluorooctyl ethyl methacrylate
- 25 (LIGHT ESTER FM-108; product by KYOEISHA CHEMICAL Co., Ltd.), 15 parts by weight of n-butyl acrylate, 65 parts by weight of 2-hydroxyethyl acrylate

and 5 parts by weight of PERBUTYL O (product by NOF CORPORATION) was dropwise added into SOLFIT under nitrogen over about 1 hour. Reaction was continued for 2 hours at 110°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer.

- 5 Weight-average molecular weight of the thus obtained fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The molecular weight thereof was 5,000 in terms of polystyrene.

- Then 85g of aqueous alkyd resin (Alorone 376; product by NIPPON SHOKUBAI Co., Ltd.) and 15g of melamine resin (WATERSOL S-695, product by DAINIPPON INK AND CHEMICALS, INCORPORATED) were mixed for 5 minutes at a rotation speed of 2,000 rpm using Labodisper. Then, into the mixed aqueous coating material, 0.1%, in terms of solid content, of the thus obtained solution containing fluorine-containing (meth)acryl type copolymer was added and then mixed at a rotation speed of 2,000 rpm for 5 minutes, obtaining an aqueous type coating material.

(Comparative Example 1)

- 150 parts by weight of SOLFIT (product by KURARAY Co., Ltd.) was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 120°C. A mixed solution of 80 parts by weight of LIGHT ESTER M-3F (product by KYOEISHA CHEMICAL Co., Ltd.), 10 parts by weight of methyl (meth)acrylate, 10 parts by weight of 2-hydroxyethyl acrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise added into SOLFIT under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, but reaction product became insoluble in

SOLFIT in the course of the reaction, being unable to obtain a solution containing fluorine-containing (meth)acryl type copolymer.

(Comparative Example 2)

150 parts by weight of SOLFIT (product by KURARAY Co., Ltd.) was  
5 introduced into a vessel fitted with a reflux condenser, thermometer, stirrer  
and dropping funnel, and the liquid inside the vessel was kept at 120°C.  
A mixed solution of 50 parts by weight of methyl methacrylate, 50 parts by  
weight of 2-hydroxyethyl acrylate and 1 part by weight of PERBUTYL D  
(product by NOF CORPORATION) was dropwise added into SOLFIT under  
10 nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C,  
obtaining a solution containing (meth)acryl type copolymer.  
Weight-average molecular weight of the thus obtained (meth)acryl type  
copolymer in the solution was determined using a gel-permeation  
chromatography. The molecular weight thereof was 11,000 in terms of  
15 polystyrene.

Then an aqueous type coating material was prepared according  
to Example 1 except that the thus obtained solution containing  
(meth)acryl type copolymer was used instead of the solution containing  
fluorine-containing (meth)acryl type copolymer in Example 1.

20 (Comparative Example 3)

200 parts by weight of SOLFIT (product by KURARAY Co., Ltd.) was  
introduced into a vessel fitted with a reflux condenser, thermometer, stirrer  
and dropping funnel, and the liquid inside the vessel was kept at 110°C.  
A mixed solution of 20 parts by weight of lauryl methacrylate, 15 parts by  
25 weight of n-butyl acrylate, 65 parts by weight of 2-hydroxyethyl acrylate  
and 5.0 parts by weight of PERBUTYL O (product by NOF CORPORATION)

was dropwise added into SOLFIT under nitrogen over about 1 hour. Reaction was continued for 2 hours at 110°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer. Weight-average molecular weight of the thus obtained  
5 fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The molecular weight thereof was 7,000 in terms of polystyrene.

Then an aqueous type coating material was prepared according to Example 4 except that the thus obtained solution containing  
10 (meth)acryl type copolymer was used instead of the solution containing fluorine-containing (meth)acryl type copolymer in Example 4.

In order to investigate the physical properties of the aqueous type coating materials obtained in Examples 1 to 4 and Comparative Examples 1 to 3, measurement of surface tension of coated layers and coating  
15 materials, evaluation of color separation prevention ability, evaluation of defoaming performance, evaluation of leveling ability, measurement of contact angles of coating materials, evaluation of wettability to a substrate, were executed.

(Measurement of surface tension of coated layers)

20 The coating material to be tested was applied on a test paper using 250•m applicator, then a standard fluid (formamide/ethylene glycol monoethyl ether) was coated using a cotton swab and then kept still for 2 seconds. Then the condition of the standard fluid coated on the test paper was observed.

25 As shown in Table 1, corresponding values for the standard fluids were used according to JIS K-6768 that prescribes a test method for

wettability of polyethylene and polypropylene film. In the case where the shape of the standard fluid on the test paper remained unchanged after 2 seconds after the standard fluid was applied on the test paper, the same procedures were repeated using another standard liquid having higher surface tension. On the contrary, when shrinkage was observed as a whole in 2 seconds, the same procedures were repeated using another standard liquid having lower surface tension. Such repetition was carried out until the shape of the standard fluid remained unchanged in 2 seconds after applying the standard fluid, thus selecting a grade of standard fluid. The surface tension of the coated layer was determined according to the value of the surface tension given to the selected standard liquid.

Table 1

Standard Liquid	Formamide (V/V %)	Ethylene glycol monoethyl ether (V/V %)	Surface Tension ( $\text{mN/cm}$ )
a	26.5	73.5	34
b	35.0	65.0	35
c	42.5	57.5	36
d	48.5	51.5	37
e	54.0	46.0	38

(Measurement of surface tension of coating materials)

A ring was immersed in a coating material. Then the ring was moved upward at a speed of 0.5 mm/min., with membrane being formed

on the ring. Surface tension of the membrane was measured using Dinometer (product by BIGCHEMIE).

(Evaluation of color separation prevention ability)

5 The coating material was applied on a test paper using a 250•m applicator and then kept still for 15 minutes. Rubbing was performed after the 15 minutes and then the test paper was dried over a night at room temperature. Color difference between the background and the rubbing portion was measured using Chroma Meter CR-200 (product by MINOLTA).

10 (Evaluation of defoaming performance)

A roller with half-long hair was immersed into a coating material to be evaluated. Then the coating material was applied on an aluminum board by rotating the roller. Defoaming phenomena was visually observed, that is, the period of time until foam disappeared from the  
15 coated portion was measured.

(Evaluation of leveling ability)

A coating material was applied on an aluminum board using a bar coater 50. Then existence or nonexistence of traces caused by the bar coater was visually observed.

20 (Measurement of contact angles of coating materials)

A droplet of about 4•L of the coating material was dropped onto a polytetrafluoroethylene (PTFE) board, and then a contact angle was measured using a contact-angle meter (product by KYOWA INTERFACE SCIENCE Co., Ltd.).

25 (Evaluation of wettability to a substrate)

A coating material was applied on a PTFE board using a 100•m

applicator. Wettability to the PTFE board was visually evaluated.

In addition, a blank test and GLANOL test were carried out for comparison. As Blank A, a coating material was prepared according to Example 1 except that the solution containing fluorine-containing (meth)acryl type copolymer was not added. As GLANOL sample A, a coating material was prepared according to Example 1 except that GLANOL 400 (product by KYOEISHA CHEMICAL Co., Ltd.), which is a 100% polyether modified silicone, was used instead of the solution containing fluorine-containing (meth)acryl type copolymer. The Blank and GLANOL samples were subjected to such evaluations as measurement of surface tension of their coated layers and of the coating materials, evaluation of color separation prevention ability, defoaming performance and leveling ability.

A blank and POLYFLOW A tests were also carried out to evaluate wettability to substrates. As Blank B, a coating material was prepared according to Example 4 except that the solution containing fluorine-containing (meth)acryl type copolymer was not added. As POLYFLOW A sample, a coating material was prepared according to Example 4 except that POLYFLOW KL245 (product by KYOEISHA CHEMICAL Co., Ltd.), which is a 100% polyether modified silicone, was used instead of the solution containing fluorine-containing (meth)acryl type copolymer.

Blank B and POLYFLOW A samples were subjected to such evaluations as measurement of surface tension of their coated layers and of the coating materials, evaluation of contact angle of the coating materials and wettability to substrates.

Results are shown in Tables 2 to 6.

Table 2

	Surface Tension ( $\bullet$ N/cm)	
	Coated Layer	Coating Material
Example 1	37	36.1
Example 2	37	35.8
Example 3	37	36.2
Example 4	34	20.1
Comp. Example 1	-	-
Comp. Example 2	37	36.7
Comp. Example 3	34	29.8
Blank A	37	36.7
Blank B	34	31.5
GLANOLA	35	35.0
POLYFLOW A	32	29.8



Table 3

	Color Separation Prevention Ability			
	• L	• a	• b	• E
Example 1	0.22	0.03	-0.19	0.29
Blank A	-0.89	-0.32	-1.70	1.94

Table 4

	Defoaming Ability (Time Period until Foam Disappears)
Example 2	13 seconds
Blank A	300 seconds

5

Table 5

	Leveling Ability (Existence or Nonexistence of Traces Caused by Bar Coater)
Example 3	Nonexistence
Blank A	Existence

Table 6

	Contact Angle of Coating Material on PTFE Board (°)	Wettability to Substrate
Example 4	38.3	wet
Comp. Example 3	61.2	no wet
Blank B	63.2	no wet
POLYFLOW A	55.2	no wet

As seen from Tables 2 to 6, surface tension of the coating materials of Examples 1 to 3 was lowered when compared with that of comparative Examples 1, 2 and Blank test. But surface tension of the coated layers was not lowered, and color separation prevention ability, defoaming ability and leveling ability thereof were improved.

The coating materials of Examples 1 to 3 have excellent properties as described above. However, in Examples 1 to 3, lowering in surface tension of the coated layers, which was observed for the coated layer of the GLANOL sample, was not observed.

Surface tension of the coating material in Example 4 was lowered when compared with Comparative Examples 3, Blank and POLYFLOW A samples, but surface tension of the coated layer thereof was not lowered. The contact angle of the coating material of Example 4 on the PTFE board was lowered, and wettability to substrates of the coating material of Example 4 was also improved.

(Application to non-aqueous coating materials)

Non-aqueous coating materials containing surface tension control

agent for coating materials of the present invention are shown in Examples 5 to 8. And non-aqueous coating materials containing surface tension control agent for coating materials outside the scope of the present invention are shown in Comparative Examples 4 to 6.

5 (Example 5)

150 parts by weight of xylene was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 120°C. A mixed solution of 5 parts by weight of LIGHT ESTER M-3F (product by KYOEISHA CHEMICAL Co., Ltd.), 55  
10 parts by weight of ethylhexyl methacrylate, 40 parts by weight of methoxy triethylene glycol methacrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise added into xylene under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, obtaining a solution containing fluorine-containing (meth)acryl type  
15 copolymer. Weight-average molecular weight of the thus obtained fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The molecular weight thereof was 11,000 in terms of polystyrene.

Next a main coating material (black) and a main coating material  
20 (white) were prepared as follows. 34g of 50% non-volatile toluene-butyl acetate solution containing an acrylpolyol resin having a hydroxyl value of 50 (ACRYDIC A-801; product by DAINIPPON INK AND CHEMICALS, INCORPORATED), 4.5g of carbon black (FW-200; product by DEGUSSA), 4.5g of 30% non-volatile pigment-dispersing agent (FLOWLEN DOPA 17;  
25 product by KYOEISHA CHEMICAL Co., Ltd.), 19.0g of thinner (xylene/butyl acetate = 70/30) and 200g of glass beads having a diameter of 1.5 to 2.0

mm were all introduced into a 225ml glass bottle, and then mixed for 1 hour using a paint shaker. After 1 hour, 71.6g of ACRYDIC A-801 was added and then the glass beads were let down and separated, thus obtaining the main coating material (black). Next, 20.5g of ACRYDIC A-801, 25.8g of titanium oxide (CR-93; product by ISHIHARA SANGYO KAISHA, Ltd.), 2.6g of pigment-dispersing agent (FLOWLEN DOPA 17; product by KYOEISHA CHEMICAL Co., Ltd.), 11.6g of thinner (xylene/butyl acetate = 70/30) and 200g of glass beads having a diameter of 1.5 to 2.0 mm were all introduced into a 225ml glass bottle and then mixed for 1 hour using a paint shaker. After 1 hour, 71.1g of ACRYDIC A-801 was added, and then the glass beads were let down and separated, thus obtaining the main coating material (white).

1.25g of the fluorine-containing (meth)acryl type copolymer solution was added into a mixture of 15g of the thus obtained main coating material (black) and 85g of the thus obtained main coating material (white), and mixed for 3 minutes at a rotation speed of 3,000 rpm using Labodisper. To 100g of the thus mixed coating material, 15.6g of SUMIDULE N-75 (product by SUMITOMO BAYER URETHANE) was further added and mixed for 2 minutes at a rotation speed of 1,000 rpm, thus obtaining a non-aqueous coating material.

(Example 6)

150 parts by weight of xylene was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 120°C. A mixed solution of 40 parts by weight of LIGHT ESTER M-3F (KYOEISHA CHEMICAL Co., Ltd.), 50 parts by weight of lauryl methacrylate, 10 parts by weight of butoxy ethyl

methacrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise added into xylene under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer.

- 5 Weight-average molecular weight of the thus obtained fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The molecular weight thereof was 35,000 in terms of polystyrene.

Next, a non-aqueous coating material was prepared according to

- 10 Example 5 except that the thus obtained solution containing fluorine-containing (meth)acryl type copolymer was used instead of the solution containing fluorine-containing (meth)acryl type copolymer in Example 5.

(Example 7)

- 15 150 parts by weight of xylene was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 120°C. A mixed solution of 15 parts by weight of LIGHT ESTER M-3F (product by KYOEISHA CHEMICAL Co., Ltd.), 35 parts by weight of ethyl hexyl methacrylate, 30 parts by weight of butoxyethyl methacrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise added into xylene under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer. Weight-average molecular weight of the thus obtained
- 20 fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The molecular
- 25

weight thereof was 35,000 in terms of polystyrene.

Next, a non-aqueous coating material was prepared according to Example 5 except that the thus obtained solution containing fluorine-containing (meth)acryl type copolymer was used instead of the  
5 solution containing fluorine-containing (meth)acryl type copolymer in Example 5.

(Example 8)

200 parts by weight of xylene was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the  
10 liquid inside the vessel was kept at 110°C. A mixed solution of 20 parts by weight of perfluorooctyl ethyl methacrylate (LIGHT ESTER FM-108; product by KYOEISHA CHEMICAL Co., Ltd.), 60 parts by weight of n-butylacrylate, 15 parts by weight of 2-hydroxyethyl acrylate and 5.0 parts by weight of PERBUTYL O (product by NOF CORPORATION) was dropwise added into  
15 xylene under nitrogen over about 1 hour. Reaction was continued for 2 hours at 110°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer. Weight-average molecular weight of the thus obtained fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The  
20 molecular weight thereof was 7,000 in terms of polystyrene.

Next, 70g of a solvent type alkyd resin (BECKOLITE M-6003-60; product by DAINIPPON INK AND CHEMICALS, INCORPORATED) and 30g of a melamine resin (SUPER-BECKAMIN L-117-60, product by DAINIPPON INK AND CHEMICALS, INCORPORATED) were mixed for 5 minutes at a rotation  
25 speed of 2,000 rpm using Labodisper. To the thus obtained non-aqueous coating material, 0.1%, in terms of solid content, of the obtained solution

containing fluorine-containing (meth)acryl type copolymer was added and then mixed for 5 minutes at a rotation speed of 2,000 rpm, obtaining a non-aqueous coating material.

(Comparative Example 4)

5           150 parts by weight of xylene was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 120°C. A mixed solution of 80 parts by weight of LIGHT ESTER M-3F (product by KYOEISHA CHEMICAL Co., Ltd.), 10 parts by weight of ethyl hexyl methacrylate, 10 parts by weight of butoxyethyl methacrylate and 1 part by weight of PERBUTYL D (product by  
10           NOF CORPORATION) was dropwise added into xylene under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, but reaction product became insoluble in xylene in the course of the reaction, being unable to obtain a solution containing fluorine-containing (meth)acryl  
15           type copolymer.

(Comparative Example 5)

          150 parts by weight of xylene was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 120°C. A mixed solution of 50 parts by  
20           weight of ethyl hexyl methacrylate, 50 parts by weight of methoxy triethylene glycol methacrylate and 1 part by weight of PERBUTYL D (product by NOF CORPORATION) was dropwise added into xylene under nitrogen over about 1 hour. Reaction was continued for 2 hours at 120°C, obtaining a solution containing (meth)acryl type copolymer.  
25           Weight-average molecular weight of the thus obtained (meth)acryl type copolymer in the solution was determined using a gel-permeation

chromatography. The molecular weight thereof was 11,000 in terms of polystyrene.

Next, a non-aqueous coating material was prepared according to Example 5 except that the thus obtained solution containing (meth)acryl type copolymer solution was used instead of the solution containing fluorine-containing (meth)acryl type copolymer in Example 5.  
(Comparative Example 6)

200 parts by weight of xylene was introduced into a vessel fitted with a reflux condenser, thermometer, stirrer and dropping funnel, and the liquid inside the vessel was kept at 110°C. A mixed solution of 20 parts by weight of lauryl methacrylate, 65 parts by weight of n-butylacrylate, 15 parts by weight of 2-hydroxyethyl acrylate and 5.0 parts by weight of PERBUTYL O (product by NOF CORPORATION) was dropwise added into xylene under nitrogen over about 1 hour. Reaction was continued for 2 hours at 110°C, obtaining a solution containing fluorine-containing (meth)acryl type copolymer. Weight-average molecular weight of the thus obtained fluorine-containing (meth)acryl type copolymer in the solution was determined using a gel-permeation chromatography. The molecular weight thereof was 7,000 in terms of polystyrene.

Next, a non-aqueous coating material was prepared according to Example 8 except that the thus obtained solution containing (meth)acryl type copolymer was used instead of the solution containing fluorine-containing (meth)acryl type copolymer in Example 8.

In order to examine properties of the non-aqueous type coating materials of Examples 5 to 8 and Comparative Examples 4 to 6, measurement of surface tension of coating materials and coated layers,



evaluation of color separation prevention ability, evaluation of defoaming performance, leveling ability (existence or nonexistence of traces caused by a bar coater), measurement of contact angles of coating materials and evaluation of wettability to a substrate were carried out under the  
5 same condition previously described in the aqueous type coating materials.

In addition, a blank test and GLANOL test were carried out for comparison. As Blank C, a coating material was prepared according to Example 5 except that the solution containing fluorine-containing  
10 (meth)acryl type copolymer was not added. And as GLANOL sample C, a coating material was prepared according to Example 5 except that GLANOL 450 (product by KYOEISHA CHEMICAL Co., Ltd.) was used instead of the solution containing fluorine-containing (meth)acryl type copolymer solution. Measurement of surface tension of the coating materials and  
15 coated layers, evaluation of color separation prevention ability, defoaming performance and evaluation of leveling ability were carried out for the Blank and GLANOL samples.

Moreover, a blank and POLYFLOW tests were carried out to evaluate wettability to substrates. As Blank D, a coating material was  
20 prepared according to Example 8 except that the solution containing fluorine-containing (meth)acryl type copolymer solution was not added. As POLYFLOW B, a coating material was prepared according to Example 8 except that POLYFLOW KL 250 (product by KYOEISHA CHEMICAL Co., Ltd.), which is a 100% polyether modified silicone, was used instead of the  
25 solution containing fluorine-containing (meth)acryl type copolymer.

Blank and POLYFLOW B samples were subjected to such

evaluations as measurement of surface tension of their coated layers as well as the coating materials, evaluation of contact angle of the coating materials and wettability to substrates. Results are shown in Tables 7 to 11.

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Table 7

	Surface Tension (•N/cm)	
	Coated Layer	Coating Material
Example 5	37	26.8
Example 6	36	26.3
Example 7	37	26.6
Example 8	31	22.1
Comp. Example 4	-	-
Comp. Example 5	36	27.3
Comp. Example 6	30	29.2
Blank C	36	27.3
Blank D	31	29.5
GLANOL B	33	26.2
POLYFLOW B	29	28.8

Table 8

	Color Separation Prevention Ability			
	• L	• a	• b	• E
Example 5	-0.07	-0.05	-0.13	0.15
Blank C	-0.92	0.08	0.21	0.92

Table 9

	Defoaming Ability (Time Period until Foam Disappears)
Example 6	10 seconds
Blank C	280 seconds

5

Table 10

	Leveling Ability (Existence or Nonexistence of Traces Caused by Bar Coater)
Example 7	Nonexistence
Blank C	Existence

Table 11

	Contact Angle of Coating Material on PTFE Board (°)	Wettability to Substrate
Example 8	22.2	wet
Comp. Example 6	51.1	no wet
Blank D	52.2	no wet
POLYFLOW B	50.1	no wet

As seen from Tables 7 to 11, surface tension of the coating materials in Examples 5 to 7 was lowered when compared with that of comparative Examples 4, 5 and Blank test. But surface tension of the coated layers of Examples 5 to 7 was not lowered, and color separation prevention ability, defoaming ability and leveling ability thereof were improved.

The coating materials of Examples 5 to 7 have excellent properties as described above. Furthermore, lowering in surface tension of the coated layers, which was observed for the coated layer of the GLANOL sample, was not observed for Examples 5 to 7.

Surface tension of the coating material in Example 8 was lowered when compared with that of Comparative Example 6, Blank sample and POLYFLOW B sample. But surface tension of the coated layer of Example 8 was not lowered, and the contact angle of Example 8 on the PTFE board was lowered. Wettability to substrates thereof was also improved.

Industrial Applicability

The surface tension control agent for coating materials of the present invention is effective in adjusting surface tension of a coated layer. A coating material containing the surface tension control agent gives a  
5 coated layer an excellent overcoatability and contamination resistance. In addition, the surface tension control agent for coating materials of the present invention provides coating materials with an excellent color separation prevention ability, antifoamability, leveling ability and wettability to substrates so that the surface tension control agent of the present  
10 invention can be used as a color separation prevention agent, defoaming agent, leveling improving agent and wettability improving agent.